
Student Number

Barker College

Physics

2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

ANSWER SHEET

Staff Involved:

- MCA*
- DJB
- MZH
- DLJ

PM WEDNESDAY 19TH AUGUST

70 COPIES

Section I – Multiple Choice
Choose the best response and fill in the response oval completely

Start Here →

1	A ○	B ○	C ○	D ○	11	A ○	B ○	C ○	D ○
2	A ○	B ○	C ○	D ○	12	A ○	B ○	C ○	D ○
3	A ○	B ○	C ○	D ○	13	A ○	B ○	C ○	D ○
4	A ○	B ○	C ○	D ○	14	A ○	B ○	C ○	D ○
5	A ○	B ○	C ○	D ○	15	A ○	B ○	C ○	D ○
6	A ○	B ○	C ○	D ○	16	A ○	B ○	C ○	D ○
7	A ○	B ○	C ○	D ○	17	A ○	B ○	C ○	D ○
8	A ○	B ○	C ○	D ○	18	A ○	B ○	C ○	D ○
9	A ○	B ○	C ○	D ○	19	A ○	B ○	C ○	D ○
10	A ○	B ○	C ○	D ○	20	A ○	B ○	C ○	D ○

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General Instructions:

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A separate data sheet, formulae sheets and Periodic Table are provided.

Total marks: 100

Section I – 20 marks (pages 3 - 14)
- Attempt Questions 1 – 20
- Allow about 30 minutes for this section

Section II – 80 marks (pages 15 - 33)
- Attempt Questions 21 - 33
- Allow about 2 hours and 30 minutes for this section

Section I

20 marks
Attempt Questions 1 – 20
Allow 30 minutes for this section

Use the multiple-choice answer sheet for Questions 1 – 20
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample   2 + 4 =   A 2   B 6   C 8   D 9

A ○   B ○   C ○   D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ●   B ~~●~~   C ○   D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

Correct

A ●   B ~~●~~   C ○   D ○

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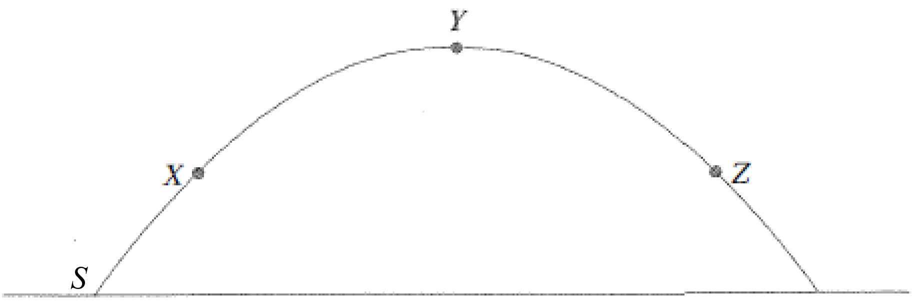
1. A ball is thrown from *S* at an angle to the horizontal as shown in the diagram below.



X, Y and Z are different positions along the ball's trajectory.

Which of the following best represents the velocity and acceleration of the ball?

	VELOCITY			ACCELERATION		
	X	Y	Z	X	Y	Z
A.	↑	zero	↓	↓	zero	↓
B.	↗	→	↘	↑	zero	↓
C.	↗	→	↘	↓	↓	↓
D.	↗	→	↘	↗	zero	↘

2. Since Millikan's oil drop experiment found that the charge on an oil drop was always a simple multiple of $-1.6 \times 10^{-19}\,\text{C}$, this showed that the smallest unit of charge must be equal to the charge on a single electron.

What did this result then enable physicists to determine?

A. The mass of an electron.

B. The mass of an oil drop.

C. The mass of an atom.

D. The mass of a proton.

3. What did the Geiger and Marsden experiment determine about the atom?

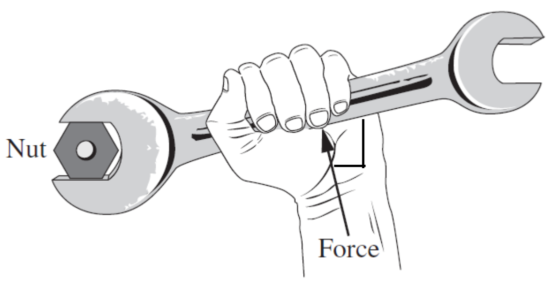
A. Most alpha particles were deflected by the gold foil suggesting it was mainly empty space, while a small number passed through the gold foil suggesting a nucleus.

B. Most alpha particles were deflected by a large angle back from the thin gold foil suggesting the atom was mainly empty space with a central nucleus.

C. Most alpha particles went through the gold foil undeflected suggesting it was mainly empty space, while a small number rebounded from the gold foil suggesting a nucleus.

D. Most beta particles went through the gold foil with no deflection or only a slight deflection, suggesting the atom had a central nucleus.

4.. A torque is applied to a nut, using a wrench.



Which change will increase the magnitude of applied torque?

A. Increasing the angle between the applied force and the wrench

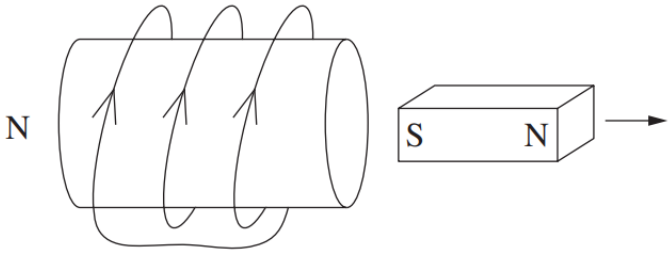
B. Decreasing the angle between the applied force and the wrench

C. Increasing the distance between the nut and the point of application of the force

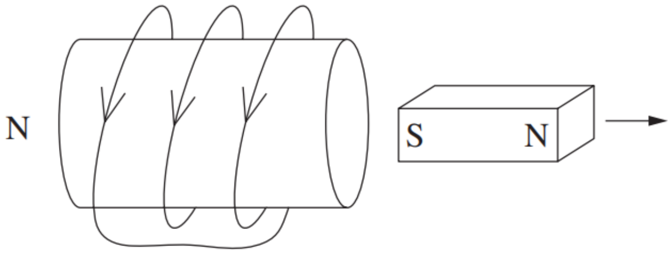
D. Decreasing the distance between the nut and the point of application of the force

5. A bar magnet is moved away from a stationary solenoid. Which diagram correctly shows the direction of the induced current in the coil and the resulting magnetic polarity of the solenoid?

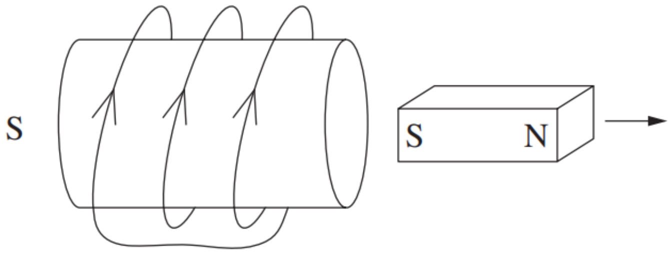
A.



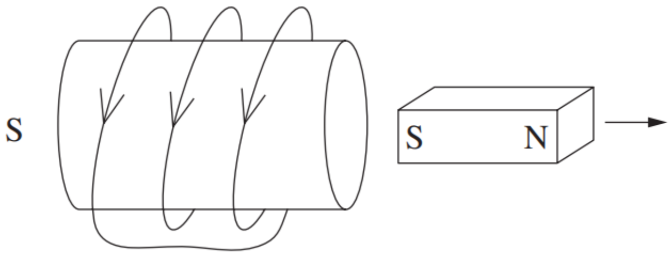
B.



C.



D.



6. Which of the following statements is INCORRECT about the work being done on an object undergoing circular motion in a horizontal plane?

   A. No work is being done as the total energy is constant due to the potential energy and kinetic energy being constant.

   B. Force and displacement are perpendicular at each instant, so there is no displacement in the direction of the force and so W= Fs = 0.

   C. No work is being done as the total energy is constant due to the fact that the speed and height of the object do not change.

   D. Displacement is in the direction of the force and so W = Fs = a constant, causing work to be done on the object.

7. Tomas is looking through the window of his hotel at the ocean. The hotel window is polarised and he is wearing a pair of sunglasses that are also polarised but at an axis 45° from that of the window. Given the light entering the window has an intensity of I_o, what is the intensity of the light as seen by Tomas? (All polarisers in this question can be regarded as ideal.)

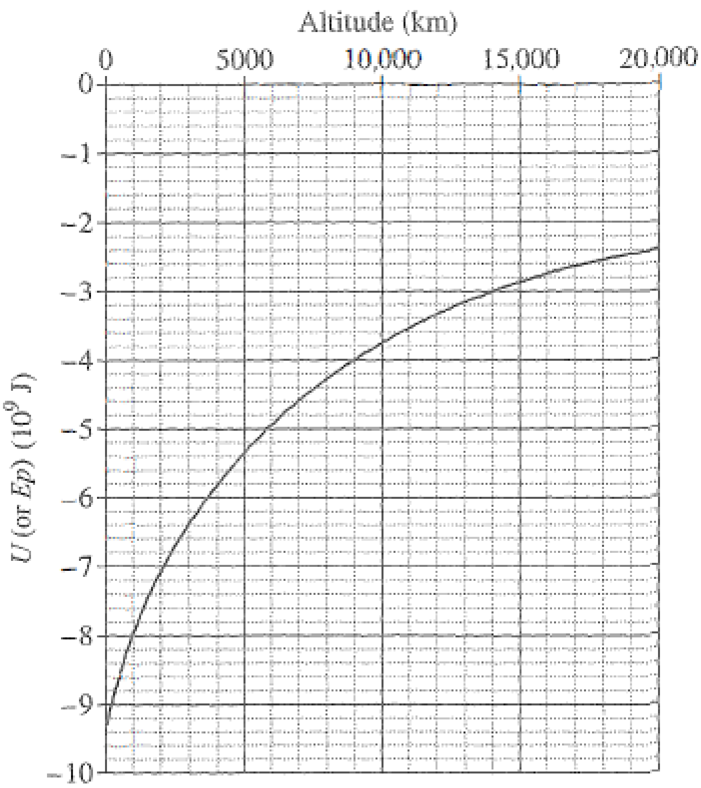
   A. 0.25 I_o

   B. 0.45 I_o

   C. 0.50 I_o

   D. 0.75 I_o

8. The Graph shows how the gravitational potential energy U (or E_p) of a satellite changes with altitude.



What is the change in gravitational potential energy of the satellite when its altitude is reduced from 14000 km to 4000 km?

A. -8.8×10^{9} J

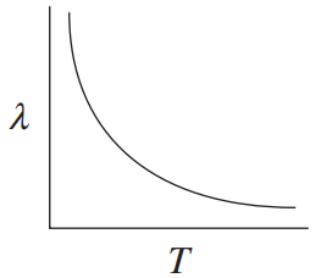
B. -2.8×10^{9} J

C. $+2.8\times10^{9}$ J

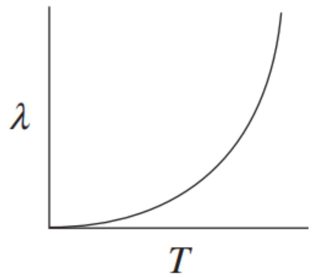
D. $+8.8\times10^{9}$ J

9. Which graph correctly shows the relationship between the surface temperature of a black body (T) and the wavelength (λ) of the maximum intensity of emitted light?

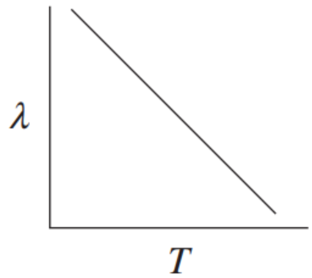
A.



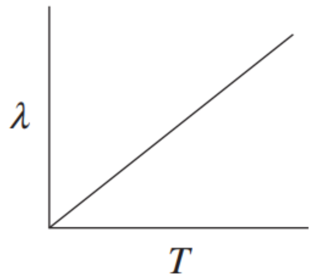
B.



C.



D.



10. A projectile is fired horizontally from a particular height with an initial velocity of 45 m s^{-1}. At the same time, a second projectile is fired horizontally from the same height with an initial velocity of 9.0 m s^{-1}. The first projectile travels a distance of 180 m. The second projectile will travel a horizontal distance of

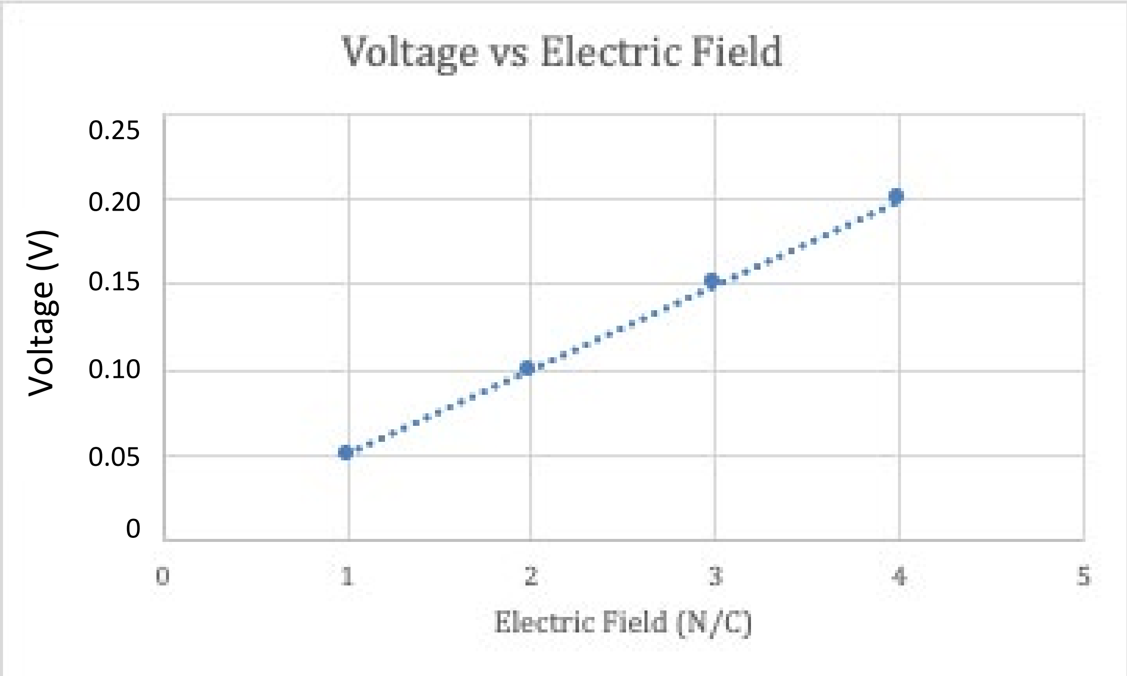
A. 9.0 m

B. 36 m

C. 45 m

D. 90 m

11. Use the graph provided to determine the distance between two charged plates in a uniform electric field.



A. 0.3 m

B. 0.5 m

C. 2.5 cm

D. 5.0 cm

12. The magnitude of the acceleration due to gravity at Earth's surface is *g*.

Planet Y has twice the mass and half the radius of Earth. Both planets can be considered to be uniform spheres.

Which one of the following best gives the magnitude of the acceleration due to gravity on the surface of Planet Y?

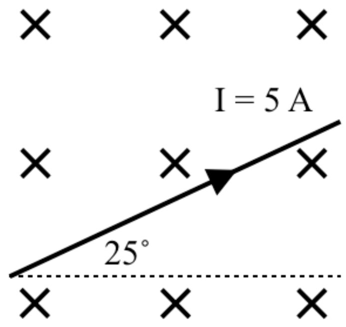
A. ½ *g*

B. 1 *g*

C. 4 *g*

D. 8 *g*

13. A current carrying conductor of length l is placed in a 0.12 T magnetic field as shown below.



The magnitude of the force on the wire can be determined by:

A. $F = (0.12)(5)(l)$

B. $F = (0.12)(5)(l)sin25$

C. $F = (0.12)(5)(l)cos25$

D. $F = (0.12)(5)(l)cos45$

14. Light from a laser is directed through a pair of slits that are 40 μm apart. If the laser light has a wavelength of 600 nm, calculate the distance between bright fringes that would be produced if projected onto a screen 1 m from the slits.

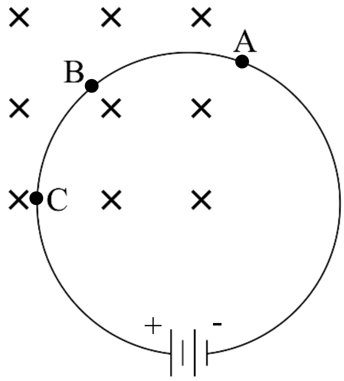
A. 3.0 cm

B. 1.5 cm

C. 0.5 cm

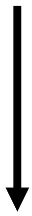
D. 1.0 cm

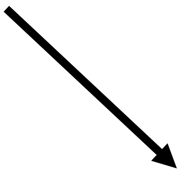
15. A length of wire labelled ABC in a uniform magnetic field is connected to an external circuit as shown below.

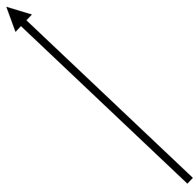


What is the direction of the force acting on the wire at point B?

A. 

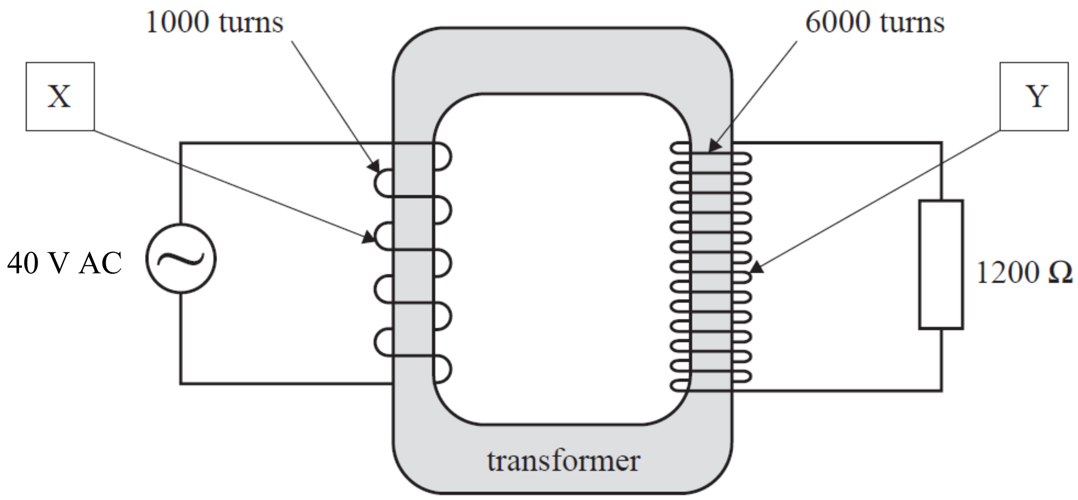
B. 

C. 

D. 

Use the following information to answer Questions16 and 17.

A 40 V AC generator and an ideal transformer are used to supply power.
The diagram below shows the generator and the transformer supplying 240 V to a resistor with a resistance of 1200 Ω.



16. Which of the following correctly identifies the parts labelled X and Y, and the function of the transformer?

	Part X	Part Y	Function of transformer
A.	primary coil	secondary coil	step-down
B.	primary coil	secondary coil	step-up
C.	secondary coil	primary coil	step-down
D.	secondary coil	primary coil	step-up

17. Which one of the following is closest to the current in the primary circuit?

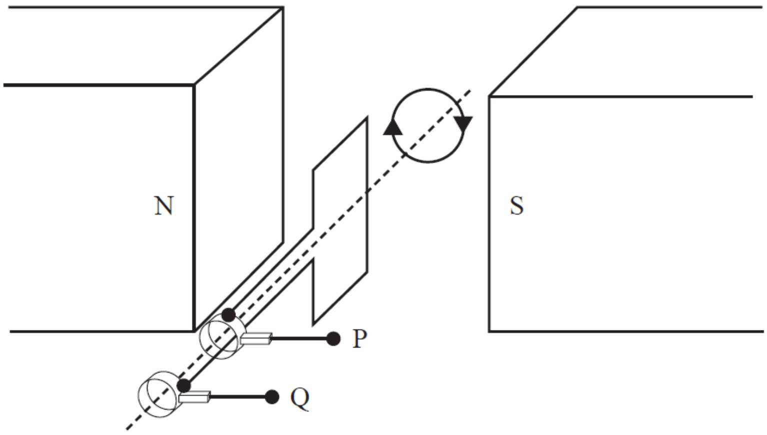
A. 0.04 A

B. 0.20 A

C. 1.20 A

D. 1.50 A

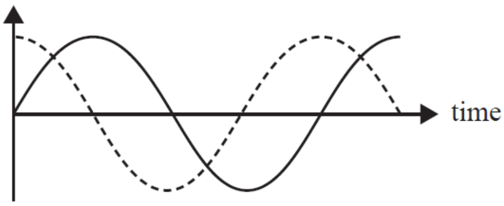
18. An electrical generator is shown in the diagram below. The generator is turning clockwise.

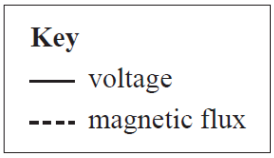


The voltage between P and Q and the magnetic flux through the loop are both graphed as a function of time, with voltage versus time shown as a solid line and magnetic flux versus time shown as a dashed line.

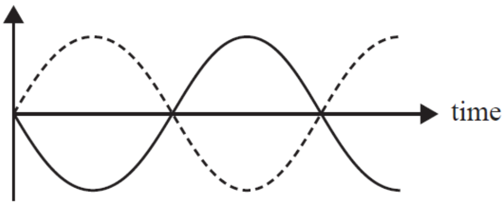
Which one of the following graphs best shows the relationships for this electrical generator?

A.

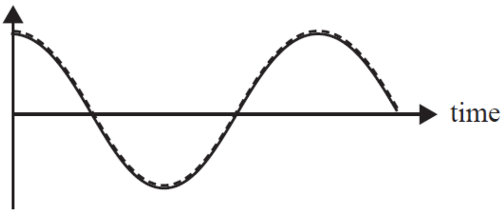




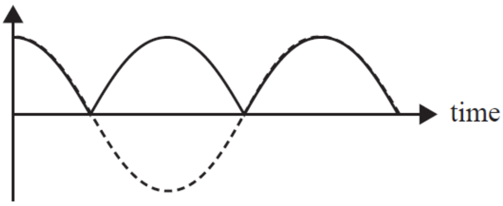
B.



C.



D.



19. A very long train is travelling close to the speed of light. An observer on a platform watches the train travel past.

Which of the following statements is true?

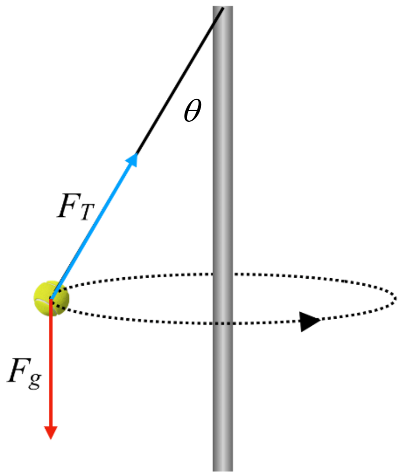
A. Time will appear to be running faster in the train according to the observer on the platform.

B. A passenger on the train and the observer on the platform both measure time slowing in the other frame of reference.

C. The platform will appear longer to the passenger on the train.

D. The observer on the platform will observe a longer train.

20. A tether ball is swinging around a pole in uniform circular motion on a horizontal plane as shown below.



Which of the following expression would correctly determine the mass of the ball?

A. $m = \dfrac{F_T \cos\theta}{g}$

B. $m = \sqrt{\dfrac{F_c r}{v}}$

C. $m = \dfrac{gr \tan\theta}{v^2}$

D. $m = \dfrac{F_c\, g}{\tan\theta}$

End of Section I

Student Number

Barker College

Physics

Section II Answer Booklet

80 marks

Attempt Questions 21 – 33

Allow about 2 hours and 30 minutes for this section

Instructions:

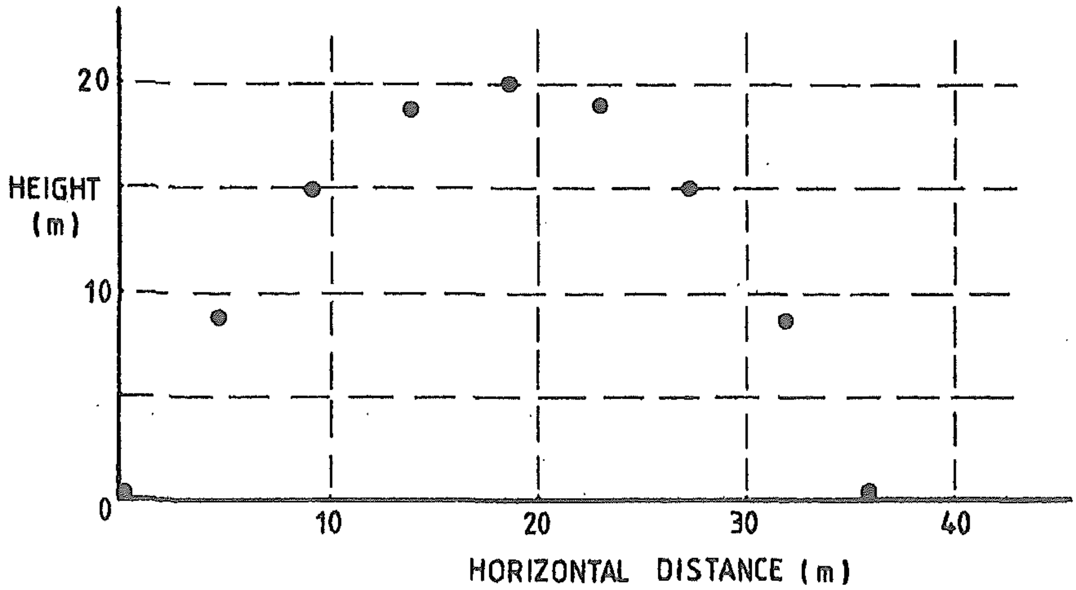
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Student Number

Question 21 (6 marks)

The diagram below is a record of a stroboscopic photograph of the motion of a projectile fired from a horizontal surface. The time interval between images is 0.5 seconds (i.e. total time is 4s). Take the acceleration due to gravity as 9.8 m s^{-2}.



When the horizontal distance travelled by the projectile is 18 m, the vertical component of its velocity is zero.

(a) What was the horizontal component of the velocity of the projectile immediately before impact with the horizontal surface? **2**

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(b) What was the vertical component of its initial velocity? **2**

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Question 21 continues on page 17

Student Number

Question 21 (continued)

(c) At what angle to the horizontal was the projectile fired? **2**

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End of Question 21

Student Number

Question 22 (4 marks)

A cyclist is travelling with uniform speed at a constant height of 3 meters on a banked curve on a theoretically frictionless circular track.

(a) Draw a free body diagram labelling the forces acting on the cyclist and showing the direction of the net force. **2**

(b) If the banked curve was at an angle of 25° with a radius of 30 m, determine the net force acting on a 70 kg cyclist. **2**

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Student Number

Question 23 (8 marks)

The moon has a mass of 7.35×10^{22} kg and a radius of 1740 km.
Use this information to answer the questions below.

(a) The condition for an object to reach escape velocity is that kinetic energy = absolute potential. Use this to derive an equation for escape velocity. **2**

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(b) Determine the escape velocity of a 200 g golf ball hit vertically upward from the surface of the moon. **1**

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(c) If a 2000 kg capsule was launched vertically with a velocity of $1200 m.s^{-1}$ from the moon's surface. It travelled vertically upwards to a height of 30km above the moon's surface, determine its velocity. (You may assume the only force acting on it is the moon's gravity). **3**

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(d) If the object was turned so it entered a perfectly circular orbit around the moon at 30 km above the moon's surface, what speed would it need to have to maintain this orbit? **2**

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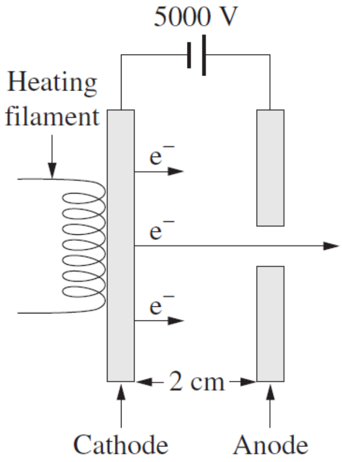
Student Number

Question 24 (2 marks)

An 'electron gun' like that used by JJ Thomson is shown.



Electrons leave the cathode and are accelerated towards the anode. (The electric field between the cathode and anode can be considered uniform.)

Show that the acceleration of the electrons as they just leave the cathode is $4 \times 10^{16}\,\text{ms}^{-2}$. **2**

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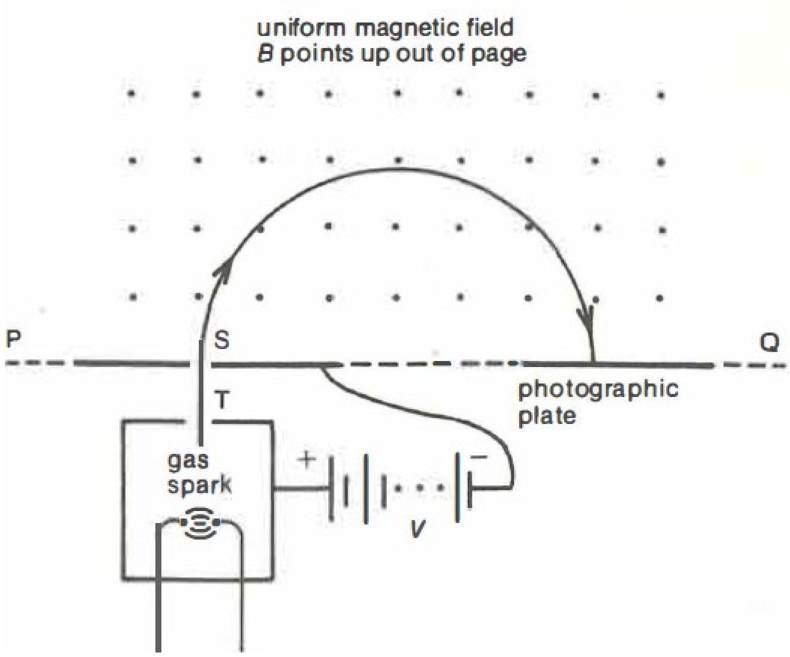
Student Number

Question 25 (5 marks)

The diagram represents a Dempster mass spectrograph. A spark discharge in a gas produces ions of mass m and carrying charge q. These drift with negligible kinetic energy through a hole T and are accelerated by a potential difference V set up between T and S. The protons pass through a small hole with speed v and enter a region of uniform magnetic field of flux density **B** at right angles to the velocity of the ions. The protons move in a semicircular path of radius R before impinging (colliding) on a photographic plate. The whole apparatus is in a vacuum.



(a) Derive an equation for the radius of the circular motion of the charged particle through the magnetic field shown in terms of *m, q* and *v.* **2**

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Question 25 continues on page 22

Student Number

Question 25 (continued)

(b) In this apparatus protons are accelerated initially by a potential difference of 250 V, then in a magnetic field of flux density 0.16 T, they undergo a circular motion.

Determine the distance the hydrogen ion strikes the photographic plate from where it entered the field. **3**

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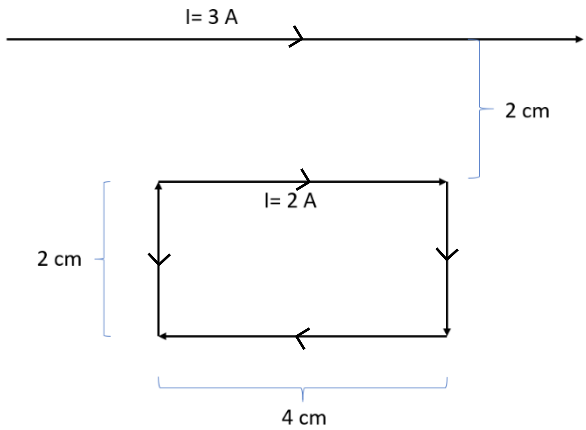
End of Question 25

Student Number

Question 26 (3 marks)

A current carrying wire near a rectangular wire loop.



Consider the situation shown in the diagram above where a wire carrying a current of 3 A is placed near a rigid rectangular loop carrying a current of 2 A (clockwise). Calculate the net force acting on the wire loop. (You may consider the wire to be parallel to the long side of the rectangle.) **3**

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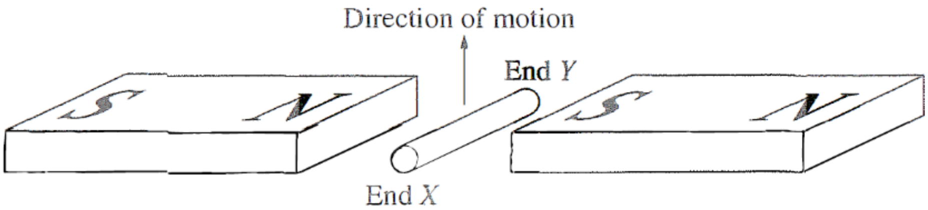
Student Number

Question 27 (4 marks)

(a) When the metal rod is moved upwards through the magnetic field as shown in the diagram, an emf is induced between the two ends.



(i) Which end of the rod is negative? **1**

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(ii) Explain how the emf is produced in the rod. **1**

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(b) An exercise bike can use magnets to slow the movement of an aluminium wheel.

Explain how the principle of induction can be used to dampen (or retard) the movement of a non-magnetic metal such as aluminium in the above example. **2**

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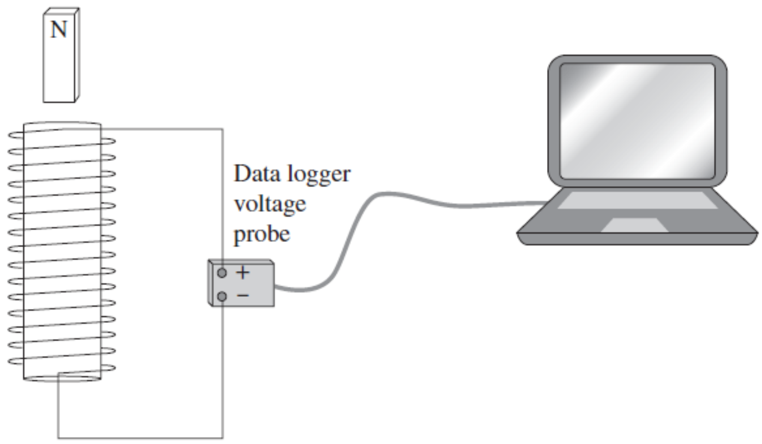
Student Number

Question 28 (4 marks)

A solenoid was connected to a data logger to measure voltage. A magnet was dropped through the solenoid from above as shown. The magnet starts from rest directly adjacent to the top of the solenoid.



(a) On the axes provided, sketch a graph showing the change in voltage as the magnet falls completely through the solenoid. **2**

(b) Explain TWO features of the shape of the curve produced with reference to the physical principles involved. **2**

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Student Number

Question 29 (7 marks)

(a) Describe Maxwell's contribution to the development of a modern model of light. **3**

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Historical measurements of *c*, the 'speed of light' (in km s^{-1})

1675	Romer and Huygens (moons of Jupiter)	220 000
1729	Bradley (aberration of light)	301 000
1849	Fizeau (toothed wheel)	315 000
1862	Foucault (rotating mirror)	298 000 $\pm$ 30
1926	Michelson (rotating mirror)	299 796 $\pm$ 4

(b) Describe TWO historical attempts to measure the speed of light and compare their accuracy. **4**

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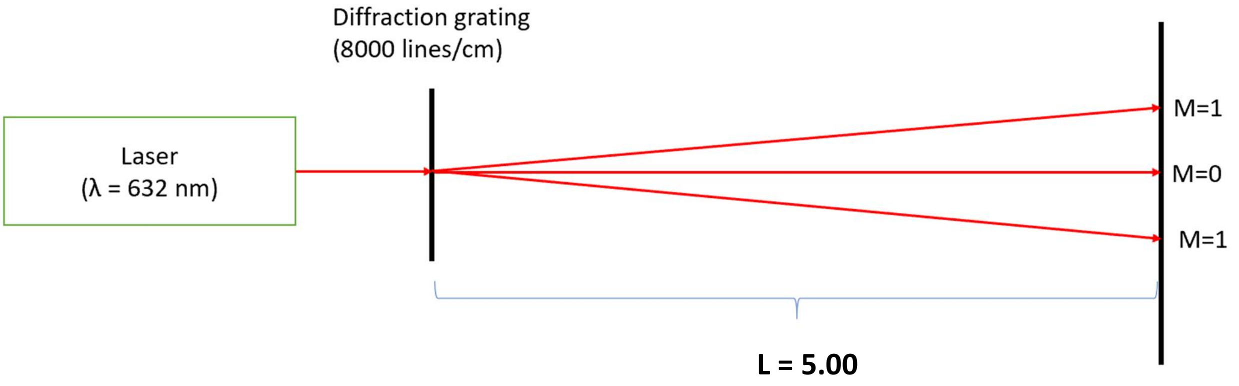
Student Number

Question 30 (5 marks)

A helium neon (λ = 632 nm) laser is shone through a diffraction grating with 8000 lines /cm. It is placed L = 5.00 m away from a screen.



(a) Determine the separation between the slits in the grating. **1**

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(b) What is the distance on the screen between the central maximum and the 1st order maximum? **2**

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(c) What is the maximum number of maxima which can appear with this set up using a helium neon laser? (hint: light cannot diffract past 90°). **2**

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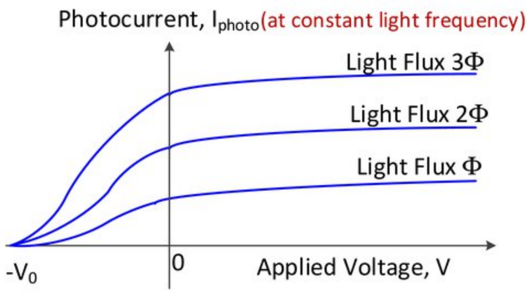
Student Number

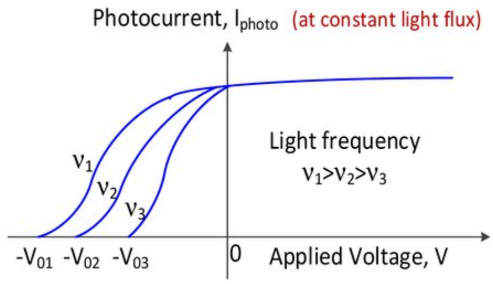
Question 31 (6 marks)

Before writing your answer to part (a), you are advised to read part (b) and (c) so you can plan accordingly.

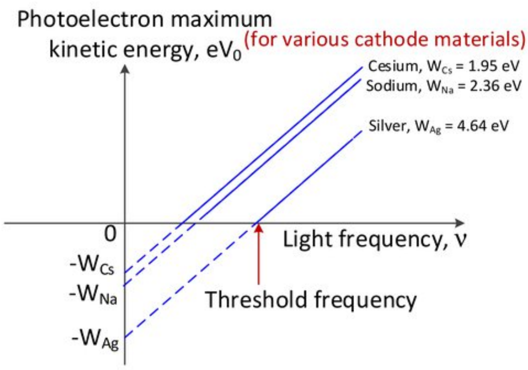
In 1902 a number of experiments were conducted into the Photoelectric effect by Philipp Lenard. The results were unexpected. Some results are shown in the graphs below.



(a)



(b)



(c)

(a) Outline TWO predictions made by the classical model, that were later shown to be <u>incorrect</u>. **2**

(1)

(2)

Question 31 continues on page 29

Student Number

Question 31 (continued)

(b) Describe what was actually observed for the TWO incorrect predictions you have identified above. **2**

(1) …………………………………………………………………………………

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(2) …………………………………………………………………………………

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(c) Give the correct quantum explanation for each of the two observations. **2**

(1) …………………………………………………………………………………

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(2) …………………………………………………………………………………

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End of Question 31

Student Number

Question 32 (11 marks)

Einstein proposed the special theory of relativity in 1905. As part of this theory he considered a number of thought experiments which predicted results which did not seem to be "common sense".

(a) Outline Einstein's thought experiment which produced the conclusion that time flows at different speeds in different frames of reference. (Include a diagram.) **4**

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Question 32 continues on page 30

Student Number

Question 32 (continued)

(b) Describe TWO pieces of experimental evidence which confirm these predictions. **3**

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(c) If a train with a rest length of 300m travels through a station at 0.8 c, what length is the train as measured by a conductor on the station platform? **2**

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(d) When an electron and the electron antiparticle (positron) collide they mutually annihilate. A positron has exactly the same mass as an electron, but is of opposite charge. They then become pure energy in the form of gamma rays. Consider Einstein's equivalence of mass and energy and use this to calculate how much energy is created by this collision. **2**

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End of Question 32

Student Number

Question 33 (15 marks)

(a) Using a diagram describe the experiment conducted by Geiger and Marsden that Rutherford interpreted to create a new model of the atom. Also describe the key features of that new atomic model. **5**

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(b) Identify TWO limitations of Bohrs model of the atoms which could not be explained using classical physics. **2**

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Question 33 continues on page 33

Question 33 (continued)

Student Number

(c) State Bohr's postulates. **3**

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(d) Determine the energy contained by a red photon released in the first line of the Balmer series. **2**

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(e) Use Rydberg again to determine the ionisation energy for Hydrogen. **2**

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(f) Calculate the de Broglie wavelengths of an electron moving with velocity $5.5\times10^{6}\,\mathrm{m.s.}^{-1}$ **1**

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End of Paper

Student Number

Barker College

Physics

2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

ANSWER SHEET

Staff Involved:
- MCA*
- DJB
- MZH
- DLJ

PM WEDNESDAY 19TH AUGUST

70 COPIES

Section I - Multiple Choice
Choose the best response and fill in the response oval completely

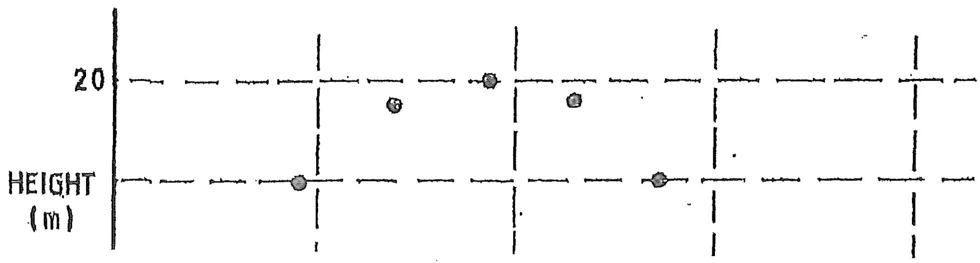
Start Here →

	A	B	C	D
1	○	○	●	○
2	●	○	○	○
3	○	○	●	○
4	○	○	●	○
5	○	○	○	●
6	○	○	○	●
7	○	○	●	○
8	○	●	○	○
9	●	○	○	○
10	○	●	○	○
11	○	○	○	●
12	○	○	○	●
13	●	○	○	○
14	○	●	○	○
15	○	○	○	●
16	○	●	○	○
17	○	○	●	○
18	●	○	○	○
19	○	●	○	○
20	●	○	○	○

Student Number

Question 21 (6 marks)

The diagram below is a record of a stroboscopic photograph of the motion of a projectile fired from a horizontal surface. The time interval between images is 0.5 seconds (i.e. total time is 4s). Take the acceleration due to gravity as 9.8 m s^{-2}.



Question 21 Markers comments

This question was very well done with most students solving the problems.

Transcription errors were an issue for messier students.

(a) What was the horizontal component of the velocity of the projectile immediately before impact with the horizontal surface? **2**

$V_h = \frac{\Delta s}{\Delta t} = \frac{36m}{8 \times 0.5s} = \frac{36}{4} = 9 ms^{-1}$ 1 sub

1 answer

(b) What was the vertical component of its initial velocity? **2**

let $V = 0 ms^{-1}$ $\therefore V = u + at$. 1 sub

$a = -10 ms^{-2}$ $0 = u - 10 \times 2$ ½ ans

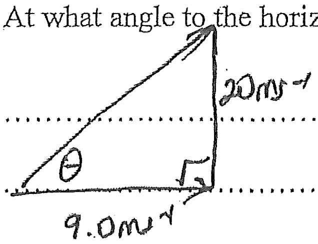
$t = 2.0s = 4 \times 0.5s$ $\therefore u = \underline{20 ms^{-1}}$ up. ½ direction

Question 21 continues on page 17

Student Number

Question 21 (continued)

(c) At what angle to the horizontal was the projectile fired? 2



$\tan\theta = \frac{20}{9}$ ⟵ (1 sub)

$\therefore \theta = 65.8°$ or $66°$ ⟵ (1 answer)

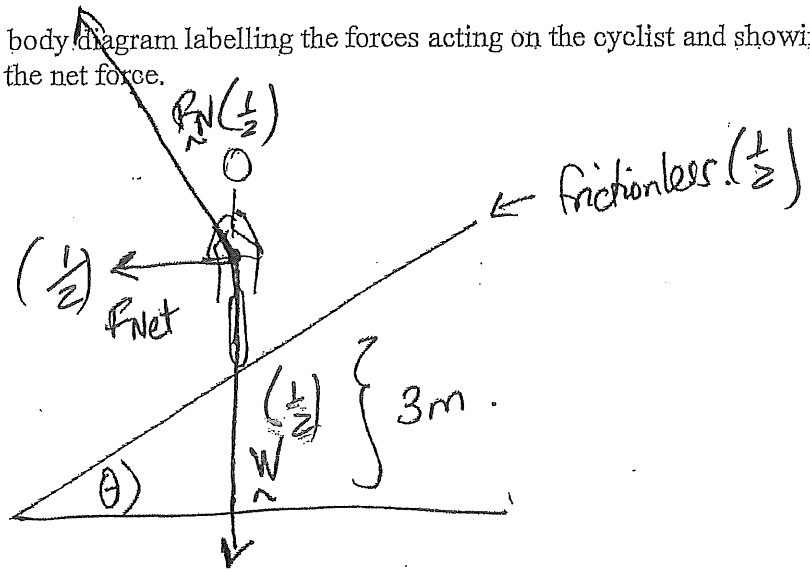
End of Question 21

Student Number

Question 22 (4 marks)

A cyclist is travelling with uniform speed at a constant height of 3 meters on a banked curve on a theoretically frictionless circular track.

(a) Draw a free body diagram labelling the forces acting on the cyclist and showing the direction of the net force. 2

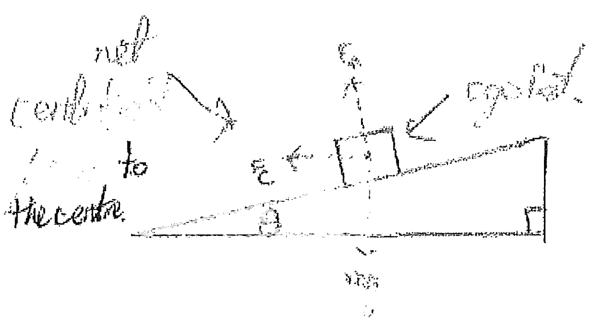


Question 22 Markers Comments

The quality of free body diagrams was poor. Many students drew in a frictional force and lost marks and many drew the resultant force as acting down the slope rather than horizontally.

½	Weight correctly drawn and labelled
½	Normal correct and labelled
½	No friction and all vectors in scale with each other
½	Resultant force correctly drawn

Student Exemplar



N.B: $F_n = \frac{mg}{\cos\theta}$

& $F_c = mg\tan\theta$

2

Student Number

Question 22 (4 marks)

A cyclist is travelling with uniform speed at a constant height of 3 meters on a banked curve on a theoretically frictionless circular track.

(a) Draw a free body diagram labelling the forces acting on the cyclist and showing the direction of the net force. **2**

(b) If the banked curve was at an angle of 25° with a radius of 30 m, determine the net force acting on a 70 kg cyclist. **2**

$mg\tan\theta = \frac{mv^2}{r} = F_c$

$\therefore \frac{v^2}{r} = 9.8\tan 25 \times 70 = F_c$ (1)

~~Brand~~ Identify correct eqn & substitute

$\therefore F_c = 70 \times 4.57$

≈ 319.9 N to the centre

$(\frac{1}{2})$ $(\frac{1}{2})$

Student Number

Question 23 (8 marks)

The moon has a mass of 7.35×10^{22} kg and a radius of 1740 km.
Use this information to answer the questions below.

(a) The condition for an object to reach escape velocity is that kinetic energy = absolute potential. Use this to derive an equation for escape velocity. 2

$KE = |GPE|$

$\frac{1}{2}\cancel{m}v^2 = \frac{GM\cancel{m}}{r}$ (1)

$\therefore V_e = \sqrt{\frac{2GM}{r}}$ (1)

(b) Determine the escape velocity of a 200 g golf ball hit vertically upward from the surface of the moon. 1

$V_e = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.35 \times 10^{22}}{1.740 \times 10^6}}$ (1) $= 2.37 \times 10^3 \text{ ms}^{-1}$

(c) If a 2000 kg capsule was launched vertically with a velocity of 1200m.s^{-1} from the moon's surface. It travelled vertically upwards to a height of 30km above the moon's surface, determine its velocity. (You may assume the only force acting on it is the moon's gravity). 3

Method 1 $KE_i = \frac{1}{2}mv^2 = \frac{1}{2} \times 2000 \times (1200)^2 = 1.44 \times 10^9 \text{ J}$ ($\frac{1}{2}$)

Use knowledge that $\boxed{g = \frac{9.8}{6}}$ $\therefore \Delta GPE = mg\Delta h = 2000 \times \frac{9.8}{6} \times 30{,}000 \text{m} = 9.8 \times 10^7 \text{ J}$ (1)

$\therefore KE_f = 1.44 \times 10^9 \text{ J} - 9.8 \times 10^7 \text{ J} = 1.342 \times 10^9 \text{ J} = \frac{1}{2}mv^2$ (1)

Method 2 (1/2) $TE = \frac{1}{2}mv^2 - \frac{GMm}{r} = 1.44 \times 10^9 - \frac{6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 2000}{1.74 \times 10^6}$ $\boxed{V = \sqrt{\frac{2 \times 1.342 \times 10^9}{2000}} = 1{,}158 \text{ ms}^{-1}}$ ($\frac{1}{2}$)

Use Energy Conservation (1) $TE = 1.44 \times 10^9 - 5.635 \times 10^9$

$TE = -4.195 \times 10^9 \text{ J} = KE + GPE = \frac{1}{2}mv^2 - \frac{6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 2000}{1.77 \times 10^6}$ (1)

$\therefore \frac{1}{2}mv^2 = 1.344 \times 10^9 \text{ J} \Rightarrow \therefore V = \sqrt{\frac{2 \times 1.344 \times 10^9}{2000}} = 1{,}159 \text{ ms}^{-1}$ ($\frac{1}{2}$)

(d) If the object was turned so it entered a perfectly circular orbit around the moon at 30 km above the moon's surface, what speed would it need to have to maintain this orbit? 2

$F_c = \frac{GM\cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}} \therefore V_o = \sqrt{\frac{GM}{r}}$ (1)

$V_o = \sqrt{\frac{6.67 \times 10^{-11} \times 7.35 \times 10^{22}}{1.770 \times 10^6 \text{m}}}$ (1)

$r_o = 1740\text{km} + 30\text{km}$

$= 1.770 \times 10^6 \text{m}$

$= 1664 \text{ ms}^{-1}$

Question 23 (c) Markers comment

This question could be done using SUVAT or energy conservation.

It was easier to do using SUVAT but either method was acceptable

Using Energy	**Using SUVAT**
½ mark for finding initial kinetic energy	1 mark for calculating the acceleration
1 mark for calculating the change in potential	1 mark for substitution
1 mark for subtracting the change in potential from initial kinetic energy	1 mark for calculation
½ for using final kinetic energy to find velocity	

Question 29 (a) – Describe Maxwell's Contributions to the development of a modern model of light.

<table>
<tr><th>Criteria</th><th>Marks</th></tr>
<tr><td>Model answer: Maxwell unification of electricity and magnetism to create electromagnetism. He created the idea of an EM wave caused by an oscillating charged particle with perpendicular E and B fields that propagates due to their mutual generation and interaction, from his quantitative model he determined the speed of the wave to be the same as the measured speed of light and therefore argued that light was an EM wave and this included a range of frequencies including both the visible and non-visible spectrum. This mathematical model allowed for light to not require a medium (though Maxwell didn't necessarily argue that at the time).

Must include a description of

- Description of the wave as an electromagnetic wave / developed electromagnetic theory / perpendicular E and B fields

And also include any one of the following:

- Description of four equations / mathematical model / quantitative model / derived speed of light as $1/\text{sqrt}(\mu_0\varepsilon_0)$
- Description of waves as self-propagating which eventually was taken to mean no need for ether
- Description of this model applying to both frequencies in the visible and non-visible
- Detailed diagram of an EM wave</td><td>3</td></tr>
<tr><td>- Description of light as an EM wave, development of EM theory, perpendicular E and B fields

OR

- Identify as an EM wave, development of EM theory, perpendicular E and B fields, and
- Describe any one other item.</td><td>2</td></tr>
<tr><td>- Description of at least any one item</td><td>1</td></tr>
</table>

Question 29 (b) – Describe two historical attempts to measure speed of light and compare their accuracy

Criteria	Marks
- Sophisticated description of two methods - Identify a similarity or difference between their values with respect to the known speed of light (on the formula sheet = ($3.00x10^8$m/s)	4
- Sophisticated description of two methods OR - Sophisticated description of one method - Identify a similarity or difference between their values with respect to the known speed of light (on the formula sheet = ($3.00x10^8$m/s) OR - Sophisticated description of one method - Offer meaningful additional insight about one method	3
- Sophisticated description of one method OR - Offer meaningful additional insight about at least one method - Identify a similarity or difference between their values with respect to the known speed of light (on the formula sheet = ($3.00x10^8$m/s) OR - Offer meaningful information about two methods	2
- Offer meaningful additional insight about at least one method OR - Identify a similarity or difference between their values with respect to the known speed of light (on the formula sheet = ($3.00x10^8$m/s)	1

Question 30 (a) – Slit separation

Criteria	Marks
- Determine the answer to be 1.25 micrometres	1

Question 30 (b) – Distance between two maximum

Criteria	Marks
- Determine the answer to be 2.53m	2
- Calculate Sin(θ), or equate $n\lambda/d=x/L$ where x is the distance between maxima. OR - Determine the answer to be 1.26m as they found the distance to the first dark fringe.	1

Question 30 (c) – Max number of wavelengths

Criteria	Marks
- Determine the answer to be 3	2
- Determined an appropriate value for $n=d/\lambda$ or equivalent.	1

Question 31 – Photo electric effect

Note: There was limited opportunity for error carried forward for this question as an incorrect answer to Part (a) significantly changed what was being asked for Part (b) and (c). When this is the case, error carried forward is not valid.

Part (a) – One mark for each clear correct outline of a valid prediction made by classical physics in relation to the photoelectric effect.

Part (b) – One mark for each description of the actual observation in relation to the photoelectric effect which contradicts the same two predictions.

Part (c) – One mark for each quantum explanation of the stated prediction. Explanations can be brief but must be more than an identification and must be clear, talk about photos is almost always essential.

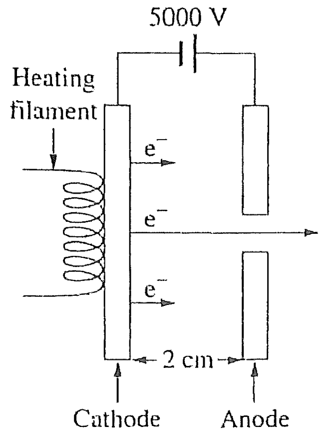
Question 32 – Outline Einstein's thought experiment

Criteria	Marks
- The method and results of a thought experiment where light moves between the ceiling and floor of a moving frame of reference relative to a stationary observer which results in a different distance travelled being observed. - Used Einstein's postulates to validly conclude that time must flow at different speeds from the results of the thought experiment. - A diagram must be included	4
- As above however, Lacking sufficient detail for methods and results of thought experiment OR - As above however, Insufficient use of postulates to conclude that time must flow at different speeds OR - As above however, Not including a diagram	3
- As above however, Missing method/results of thought experiment, - As above however, missing explanation of how through postulates can conclude that time must flow at different speeds. OR - As above however, Lacking sufficient detail for methods and results of thought experiment, and - As above however, Insufficient use of postulates to conclude that time must flow at different speeds	2
- Some detail about method/results OR - Some details about conclusion OR - Outlines one of Einstein's other thought experiments (e.g. relating to Simultaneity) in an effective and detailed manner.	1

Student Number

Question 24 (2 marks)

An 'electron gun' like that used by JJ Thomson is shown.



Electrons leave the cathode and are accelerated towards the anode. (The electric field between the cathode and anode can be considered uniform.)

Show that the acceleration of the electrons as they just leave the cathode is $4\times10^{16}\,ms^{-2}$. 2

$F = q\underset{\sim}{E} = ma$ (1)

$\therefore a = \frac{q\underset{\sim}{E}}{m} = \frac{q\left(\frac{V}{d}\right)}{m} = \frac{1.6\times10^{-19}\,C \times \frac{5000}{2.0\times10^{-2}}}{9.11\times10^{-31}\,kg}$

$a = \underline{\underline{4.39\times10^{16}\,ms^{-2}}}$ (1)

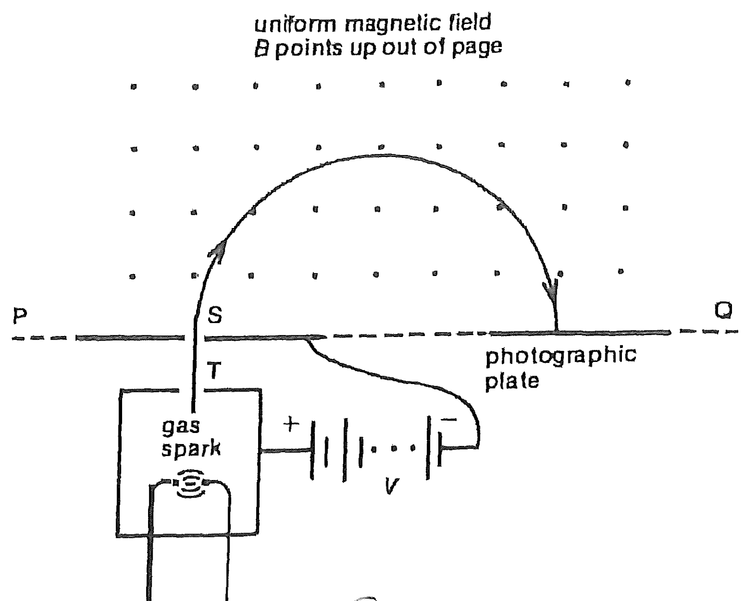
(1) - For calculating the Electric field
(1) - For finding the acceleration

* Well done - most people got full marks

Student Number

Question 25 (5 marks)

The diagram represents a Dempster mass spectrograph. A spark discharge in a gas produces ions of mass m and carrying charge q. These drift with negligible kinetic energy through a hole T and are accelerated by a potential difference V set up between T and S. The protons pass through a small hole with speed v and enter a region of uniform magnetic field of flux density **B** at right angles to the velocity of the ions. The protons move in a semicircular path of radius R before impinging (colliding) on a photographic plate. The whole apparatus is in a vacuum.



(1)

(a) Derive an equation for the radius of the circular motion of the charged particle through the magnetic field shown in terms of *m*, *q* and *V*. 2

$F_c = qvB = \frac{mv^2}{r}$ $\therefore \boxed{r = \frac{mv}{qB}}$ (1)

$\frac{1}{2}mv^2 = qV$ $\therefore v = \sqrt{\frac{2qV}{m}}$

$\therefore r = \frac{m\sqrt{\frac{2qV}{m}}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$

Question 25 continues on page 22

(1) To equate F_c with F_B

(1) For correctly re-arranged with r the subject

Very well done

Student Number

Question 25 (continued)

(b) In this apparatus protons are accelerated initially by a potential difference of 250 V, then in a magnetic field of flux density 0.16 T, they undergo a circular motion.

Determine the distance the hydrogen ion strikes the photographic plate from where it entered the field. 3

$r = \frac{1}{B}\sqrt{\frac{2mV}{q}}$ $\therefore$ $r = \frac{1}{0.16}\sqrt{\frac{2 \times 1.67\times10^{-27} \times 250V}{1.6\times10^{-19}C}}$

1

$r = 1.42\times10^{-2} m$ — 1

$\therefore$ distance $= 2\times r = 2 \times 1.42\times10^{-2} m$

$= 2.85\times10^{-2} m$

1

If V = voltage is sub in for v = velocity then No mark

Do not get marks for $v = \frac{mv}{Bq}$ without showing how 'v' is determined - or a need to find 'v'

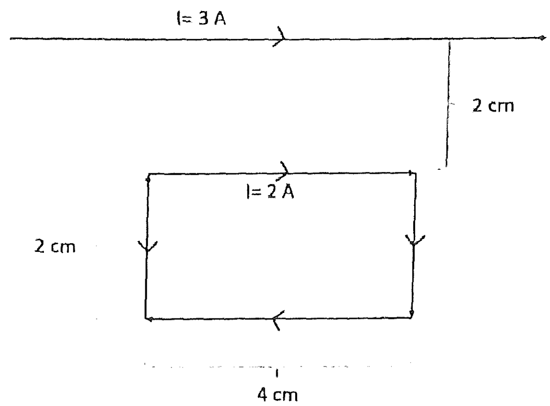
End of Question 25

* Quite well done
* A few didn't realise they needed to double the radius.

Student Number

Question 26 (3 marks)

A current carrying wire near a rectangular wire loop.



Consider the situation shown in the diagram above where a wire carrying a current of 3 A is placed near a rigid rectangular loop carrying a current of 2 A (clockwise). Calculate the net force acting on the wire loop. (You may consider the wire to be parallel to the long side of the rectangle.) 3

$F_{AB} = \frac{kI_1I_2l}{r} = \frac{2.0\times10^{-7}\times3\times2\times4\times10^{-2}}{2\times10^{-2}}$ attraction

$= 2.4\times10^{-6}$ N upwards (1)

$F_{CD} = \frac{kI_1I_2l}{r} = \frac{2.0\times10^{-7}\times3\times2\times4\times10^{-2}}{4.0\times10^{-2}}$

$= 1.2\times10^{-6}$ N downwards (1)

$\therefore F_{Net} = 1.2\times10^{-6}$ N upwards (1)

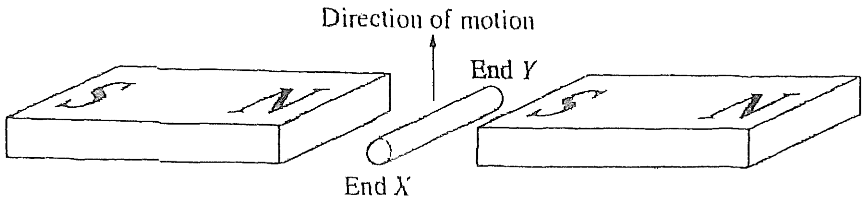
must have direction to get this mark

* Many only did part 1
* Quite a few sub values incorrectly. wrong 'l' and 'r'

Student Number

Question 27 (4 marks)

(a) When the metal rod is moved upwards through the magnetic field as shown in the diagram, an emf is induced between the two ends.



(i) Which end of the rod is negative? 1

X

1

(ii) Explain how the emf is produced in the rod. 1

A change in flux experienced by the rod.

1

(b) An exercise bike can use magnets to slow the movement of an aluminium wheel. ~~The amount of force acting to oppose the motion will be proportional to the speed of the wheel.~~

Explain how the principle of induction can be used to dampen (or retard) the movement of a non-magnetic metal such as aluminium in the above example. 2

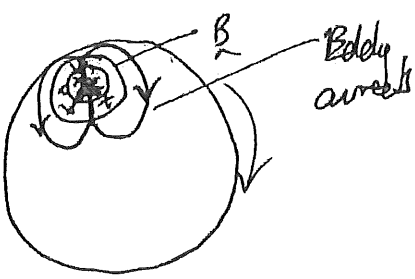
1

Or conservation of energy

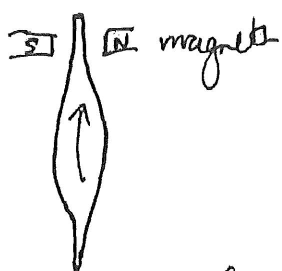
1

This is an example of electromagnetic braking. As the wheel spins a magnetic field is applied to a region as shown in Fig 1. The bulk metal experiences a change in flux (or) so an Emf is set up across the B region. In the bulk metal eddy currents will circulate as shown. These will act to oppose the change in flux (Lenz's Law) and slow the wheel. The faster the wheel spins the greater the flux change and the larger the induced currents and braking.

1



Al bike wheel side view Fig 1

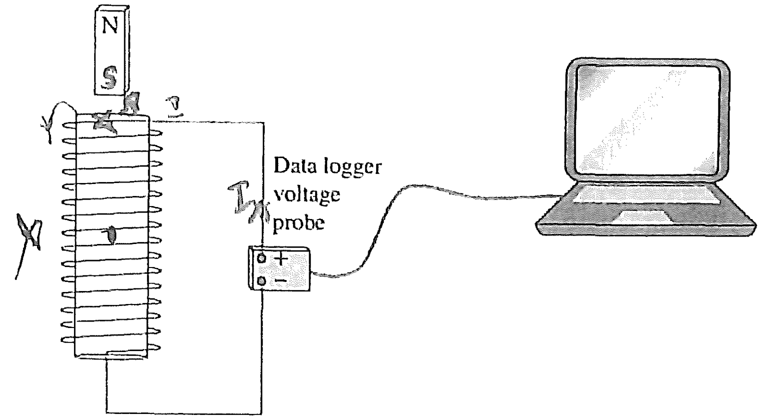


End view of bike wheel.

Student Number

Question 28 (4 marks)

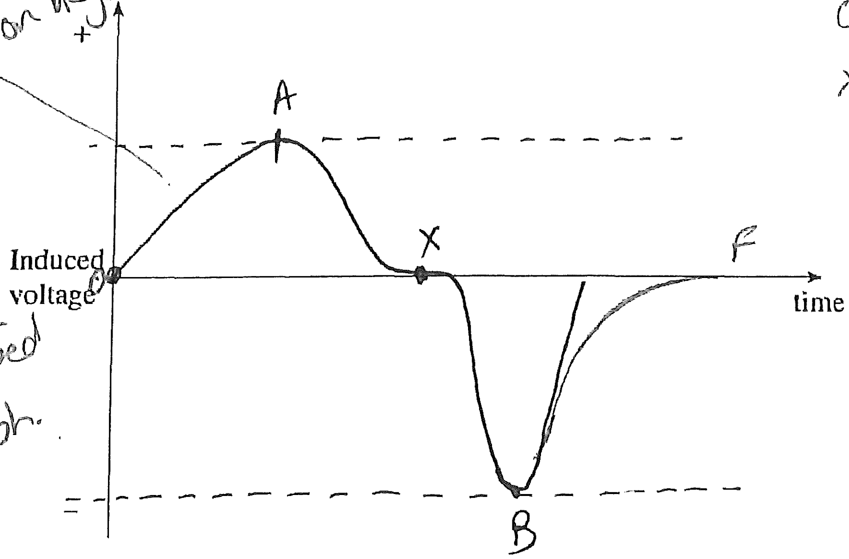
A solenoid was connected to a data logger to measure voltage. A magnet was dropped through the solenoid from above as shown. The magnet starts from rest directly adjacent to the top of the solenoid.



* Very poorly done
* (a) did not affect (b)
* If students had a physics explanation in (b) of the graph in (a) they could score

(a) On the axes provided, sketch a graph showing the change in voltage as the magnet falls completely through the solenoid. 2

Could have the graph on neg side initially then swap to positive



O – X – (1)
X – F – (1)
must be bigger amplitude

Many students simply described their graph.

(b) Explain TWO features of the shape of the curve produced with reference to the physical principles involved. 2

* X – will be when magnet is at the centre. The Emf caused by N at top and S at bottom will cancel out
* A peak is lower than B peak as magnet speeds up so greater rate of change in flux, so higher voltage
* Features get closer together as magnet speeds up

12 Physics 2020	Marking Guide for Questions 32b - 33
Trial Examination	Marked by D. Johnston

Question 32 (b) (3 marks)

CRITERIA	Key	MARKS
Student describes TWO experiments which confirmed predictions of time dilation, e.g. Hafele-Keating atomic clocks, atmospheric muon decay	E1, E2	1 per each
Student provides adequate detail and is accurate	D1, D2	½ per each

Notes from marker:

- Students are advised to use these examples given in the syllabus:
  - observations of cosmic-origin muons at the Earth's surface
  - atomic clocks (Hafele–Keating experiment)
- Half-mark awarded *at marker's discretion* for a semblance of a valid response.
- Detail is key; better responses included reference to such as that the atomic clocks had been synchronised on the ground prior, to ensure that valid conclusions could be made when compared after the experiment.
- Students should use extra writing pages if necessary. Some responses were crammed into the allocated space and probably sacrificed detail.

Exemplar:

(b) Describe TWO pieces of experimental evidence which confirm these predictions. 3

1. Mouns, as they travel at 0.996c, but only have a life span of around 2.2×10^{-6} s, with ~~??~~ only 5% of mouns predicted to reach the surface, were actual 75% make it to the surface, due to time dilation. 2. 3 atomic clocks were made, 1 stayed stationary and the other 2 ~~flew~~ flew different ways around the earth (east to west or west to east) the difference in time between the clocks, relative to the stationary clock was due to time dilation at speed.

E1 D1
E2 D2

(c) If a train with a rest length of 300m travels through a station at 0.8 c, what length is

Question 32 (c) **(2 marks)**

CRITERIA	MARKS
Student identifies 300 m as the 'rest length' by correct substitution into a valid equation.	1
Student states 180 as magnitude for relativistic length	½
Student states 'metre' (m) as standard unit for length	½

Notes from marker:

- Some students were putting the Lorentz factor as the denominator. Always confirm the equation with a quick glance at the formulae sheet.
- Half-mark applicable if no explicit substitution of "300" into equation but all else correct.

Suggested response:

If a train with a rest length of 300m travels through a station at 0.8 c, what length is the train as measured by a conductor on the station platform?

$l_v = l_0\sqrt{1-\frac{v^2}{c^2}} = 300\sqrt{1-0.8^2}$

$= 180m$

Question 32 (d) **(2 marks)**

CRITERIA	MARKS
Student substitutes combined mass of proton and electron as twice mass of electron (i.e. $2 \times 9.109 \times 10^{-31}$ kg)	1
Student states energy of collision as 1.64×10^{-13} J	1

Notes from marker:

- Units not assessed here, though should always be included.
- Alternative was to calculate the energy equivalence of a single electron and then double.

Suggested response:

$E = mc^2 = (m_{e^+} + m_{e^-})c^2$

$= (9.11\times10^{-31}\times 2)\times(3\times10^8)^2$

$= 1.64\times10^{-13}$ Joules

Question 33 (a) (5 marks)

CRITERIA	Key	MARKS
Student draws a valid diagram depicting the Geiger-Marsden experiment.	D	1 = detailed ½ = lacks detail
Student correctly describes the Geiger-Marsden experiment and observations.	E	2 = detailed 1 = lacks detail
Student correctly describes key features of new atomic model according to Rutherford's interpretation of results, including sufficient detail of the proposed properties of the nucleus and the atom consisting mostly of empty space.	M	2 = detailed 1 = lacks detail

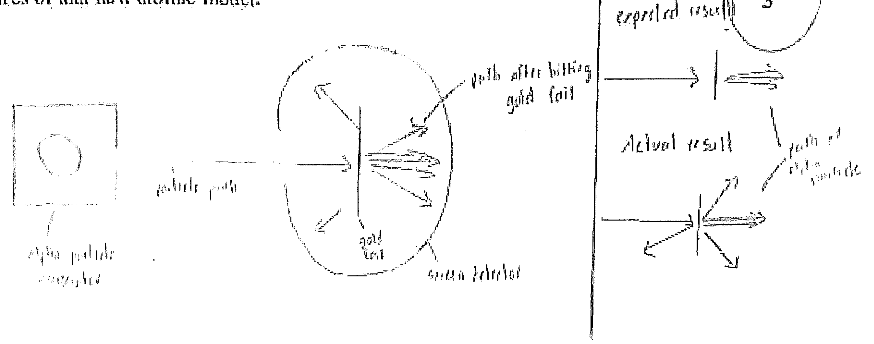
Notes from marker:

- Students should in future refer to the scintillation screen (i.e. flash of light when struck by charged particle) as allowing detection of alpha particle deflection through many angles.
- The gold foil was thicker than most students were suggesting, probably in the order of thousands of gold atoms.
- Common misconception in student responses: Most of the alpha particles passing through undeflected *was expected* based upon the Thomson model (insufficient concentration of charge to establish enough electrostatic repulsion). This did not – in and of itself – give rise to the notion of the atom being mostly empty space.

Exemplar:

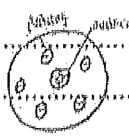
(a) Using a diagram describe the experiment conducted by Geiger and Marsden that Rutherford interpreted to create a new model of the atom. Also describe the key features of that new atomic model.

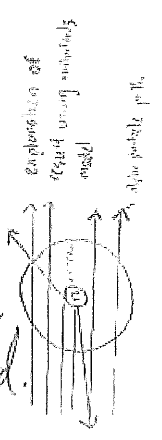
D ½
E 2
M 2



Alpha particles were shot at a thin piece of gold ~~film~~ foil (about ~~4 atoms~~ 1000 thick) and the deflected path that the particle took was recorded through a screen detector (it recorded both changed and was where the particle was not altered). They noticed that most particles went straight through undeflected however some deflected at large angles (about 1 in ~~10000~~ ~~straight back~~) angles > 90°.

From this, Rutherford ~~concluded~~ dismissed the plum pudding model and stated that an atom was mostly empty space and had a positively charged nucleus with electrons surrounding it. While he couldn't completely explain the nucleus he came to this conclusion because it matched the drastic ~~path~~ change of path that the particles were experiencing.





good.

(b) Identify TWO limitations of Bohrs model of the atoms which could not be explained

Question 33 (b) **(2 marks)**

CRITERIA	MARKS
Student states two valid limitations of the Bohr atomic model.	1 per each

Notes from marker:

- This is a classic rote-learned response. Students who did not receive two marks here simply had not learned the material.
- Vague or ambiguous statements generally were not accepted.
- Marks awarded only if correct understanding conveyed through response.
    - E.g. "… could not explain hyperfine spectral lines, known as the Zeeman effect." would receive only one mark because student has not shown understanding that these are two distinct phenomena.

Exemplar:

(b) Identify TWO limitations of Bohrs model of the atoms which could not be explained using classical physics. 2

Bohrs model was only applicable to the hydrogen atom and did not work with multielectron atoms. Bohrs model also did not explain the zeeman effect or ultrafine spectral lines.

good

Question 33 continues on page 33

Question 33 (c) **(3 marks)**

CRITERIA	MARKS
Student correctly states Bohr's postulates (with sufficient detail)	1 per each

Notes from marker:

- Overall, this was answered poorly by the cohort considering it can be rote-learned.
- Depending on the source of information, students may either have learned that Bohr's postulates consist of three or four statements. Any valid three were accepted.
- Half-marks applicable if lacking detail or relevant equation (marker's discretion).
    - As Mr Arnot says, "If there's a relevant equation, it should always be included in your response."

Exemplar:

(c) State Bohr's postulates. 3

1. Electrons orbit the nucleus in circular paths, held by electrostatic attraction.
2. Electrons exist in stationary energy states, where they cannot absorb/emit energy.
3. The angular momentum of electrons is quantised: $mvr = \frac{nh}{2\pi}$
4. Electrons absorb and emit energy in a quantised manner according to Planck's hypothesis: $\Delta E = E_i - E_f = hf$.

V. good

Question 33 (d) **(2 marks)**

CRITERIA	MARKS
Student substitutes $n_i = 3$ into Rydberg equation	1
Student shows logical substitution into $E = hf = \frac{hc}{\lambda}$, using the wavelength correctly determined by Rydberg equation.	1

Notes from marker:

- Correct photon energy desirable but not assessed in this question.
- Several students not carefully reading the question – leaving their answer as the wavelength of the photon.
- No marks awarded if student assumed a wavelength for "red" without applying Rydberg.
- Marks withheld if unclear as to the logic being followed by student.

Exemplar

(d) Determine the energy contained by a red photon released in the first line of the Balmer series. **2**

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ $\left(\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)\right)$

$\lambda = \left(R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)\right)^{-1}$ $E = hf$ $f = \frac{c}{\lambda} = \frac{3\times10^8}{6.56\times10^{-7}}$

$= 6.56\times10^{-7}$ m $E = hf = h \times \frac{3\times10^8}{6.56\times10^{-7}}$

$= 656$ nm $= 3.03\times10^{-19}$ J

good

Question 33 (e) **(2 marks)**

CRITERIA	MARKS
Student substitutes $n_i = \infty$ or $n_f = \infty$ into Rydberg equation	1
Student shows logical progression to ionisation energy 2.18×10^{-18} J	1

Notes from marker:

- A more challenging question. Students had to consider what it means to "ionise" an atom. (Recalling Year 10 Chemistry, ionisation occurs when an electron 'is removed' from an atom, i.e. it is promoted to an infinite energy level above the nucleus)
- Marks withheld if unclear as to the logic being followed by student.

Exemplar:

(e) Use Rydberg again to determine the ionisation energy for Hydrogen.

$\frac{1}{\lambda} = R\left(\frac{1}{1} - \frac{1}{\infty}\right)$ $f = 3.291 \times 10^{15}$

$E = hf$

$= (1.097 \times 10^{7})$ $= 2.18 \times 10^{-18}$ J

$\lambda = 91.2 \times 10^{-9}$ $= 13.6$ eV

Question 33 (f) **(1 mark)**

CRITERIA	MARKS
Student substitutes mass of electron correctly into de Broglie equation	½
Student includes valid unit for length (e.g. metre)	½

Notes from marker:

- Always show substitutions, even for 1-markers.
- Always include a valid unit of measurement.

Suggested response:

Calculate the de Broglie wavelengths of an electron moving with velocity 5.5×10^{6} m.s.$^{-1}$ 1

$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{ J.s}}{9.11 \times 10^{-31} \text{ kg} \times 5.5 \times 10^{6} \text{ ms}^{-1}} = 1.32 \times 10^{-10}$ m